

**CLAIMS**

What is claimed is:

SUB A, >

1. A direct antifreeze cooled fuel cell for producing electrical energy from a reducing fluid and a process oxidant stream, comprising:

- a. an electrolyte secured between an anode catalyst and a cathode catalyst;
- b. a porous anode substrate secured in direct fluid communication with the anode catalyst for passing the reducing fluid stream adjacent the anode catalyst and a wetproofed cathode support means secured in direct fluid communication with the cathode catalyst for passing the process oxidant stream adjacent the cathode catalyst;
- c. a porous water transport plate secured in direct fluid communication with the wetproofed cathode support means; and,
- d. a direct antifreeze solution passing through the porous water transport plate for cooling the fuel cell, wherein the direct antifreeze solution is an organic antifreeze solution that does not wet the wetproofed cathode support means and that is non-volatile at cell operating temperatures.

2. The direct antifreeze cooled fuel cell of Claim 1, wherein the antifreeze solution is an alkanetriol direct antifreeze solution.

3. The direct antifreeze cooled fuel cell of Claim 1, wherein the antifreeze solution is an alkanetriol direct antifreeze solution selected from the group consisting of glycerol, butanetriol, and pentanetriol.

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4. The direct antifreeze cooled fuel cell of Claim 1, wherein the fuel cell includes a pressure control means for maintaining a positive pressure differential between the process oxidant stream passing through the fuel cell and
- 5 the antifreeze solution passing through the porous water transport plate so that the process oxidant stream within the fuel cell is at a greater pressure than the antifreeze solution within the water transport plate.

5. The direct antifreeze cooled fuel cell of Claim 1, wherein the process oxidant stream enters an oxidant inlet of the fuel cell at greater than approximately 30% relative humidity at a temperature at the oxidant inlet.

6. The direct antifreeze cooled fuel cell of Claim 1, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a wetproofed cathode substrate and the cathode catalyst.

7. The direct antifreeze cooled fuel cell of Claim 1, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a cathode substrate and the cathode catalyst.

8. The direct antifreeze cooled fuel cell of Claim 1, wherein the electrolyte is a proton exchange membrane.

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9. A direct antifreeze cooled fuel cell for producing electrical energy from a reducing fluid and a process oxidant stream, comprising:
- 5 a. an electrolyte secured between an anode catalyst and a cathode catalyst;
- b. a wetproofed anode support means secured in direct fluid communication with the anode catalyst for passing the reducing fluid stream

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- 10 adjacent the anode catalyst and a wetproofed  
15 cathode support means secured in direct fluid  
communication with the cathode catalyst for  
passing the process oxidant stream adjacent the  
cathode catalyst;
- 15 c. a porous anode water transport plate secured in  
direct fluid communication with the wetproofed  
anode substrate means, and a porous cathode water  
transport plate secured in direct fluid  
communication with the wetproofed cathode support  
means; and,
- 20 d. a direct antifreeze solution passing through the  
porous anode and cathode water transport plates  
for cooling the fuel cell, wherein the antifreeze  
solution is a special direct antifreeze solution  
having;
- 25 i. a freezing point of at least  $-20^{\circ}\text{F}$ ;
- ii. a surface tension greater than 60  
dyne/cm at an operating temperature of  
the fuel cell;
- 30 iii. a partial pressure of antifreeze above  
the solution at the cell operating  
temperature that is less than 0.005 mm  
Hg; and,
- 35 iv. a capacity of being oxidized by the  
anode and cathode catalysts at fuel  
cell voltages.
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10. The direct antifreeze cooled fuel cell of Claim 9,  
wherein the antifreeze solution is an alkanetriol direct  
antifreeze solution.

11. The direct antifreeze cooled fuel cell of Claim 9,  
wherein the antifreeze solution is an alkanetriol direct  
antifreeze solution selected from the group consisting of

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glycerol, butanetriol, and pentanetriol.

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12. The direct antifreeze cooled fuel cell of Claim 9, wherein the fuel cell includes a pressure control means for maintaining a positive pressure differential between the process oxidant stream passing through the fuel cell and
- 5 the antifreeze solution passing through the porous anode and cathode water transport plates so that the process oxidant stream within the fuel cell is at a greater pressure than the antifreeze solution within the water transport plates.

13. The direct antifreeze cooled fuel cell of Claim 9, wherein the process oxidant stream enters an oxidant inlet of the fuel cell at greater than approximately 30% relative humidity at a temperature of the oxidant inlet.

14. The direct antifreeze cooled fuel cell of Claim 9, wherein the wetproofed cathode support means includes a wetproofed cathode diffusion layer secured between a cathode substrate and the cathode catalyst, and the
- 5 wetproofed anode support means includes a wetproofed anode diffusion layer secured between an anode substrate and the anode catalyst.

15. The direct antifreeze cooled fuel cell of Claim 9, wherein the electrolyte is a proton exchange membrane.

16. A direct antifreeze cooled fuel cell for producing electrical energy from a reducing fluid and a process oxidant stream, comprising:

- 5 a. a proton exchange membrane electrolyte secured between an anode catalyst and a cathode catalyst;
- b. a wetproofed anode support means secured in direct fluid communication with the anode

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10 catalyst for passing the reducing fluid stream  
adjacent the anode catalyst and a wetproofed  
cathode support means secured in direct fluid  
communication with the cathode catalyst for  
passing the process oxidant stream adjacent the  
cathode catalyst;

15 c. a porous anode water transport plate secured in  
direct fluid communication with the wetproofed  
anode support means, and a porous cathode water  
transport plate secured in direct fluid  
communication with the wetproofed cathode support  
means; and,

20 d. an alkanetriol direct antifreeze solution passing  
through the porous anode and cathode water  
transport plates for cooling the fuel cell.

5 17. The direct antifreeze cooled fuel cell of Claim 16,  
wherein the fuel cell includes a pressure control means for  
maintaining a positive pressure differential between the  
process oxidant stream passing through the fuel cell and  
the antifreeze solution passing through the porous anode  
and cathode water transport plates so that the process  
oxidant stream within the fuel cell is at a greater  
pressure than the antifreeze solution within the water  
transport plates.

18. The direct antifreeze cooled fuel cell of Claim 17,  
wherein the process oxidant stream enters an oxidant inlet  
of the fuel cell at greater than approximately 30% relative  
humidity at a temperature at the oxidant inlet.

19. The direct antifreeze cooled fuel cell of Claim 18,  
wherein the wetproofed cathode support means includes a  
wetproofed cathode diffusion layer secured between a  
cathode substrate and the cathode catalyst, and the

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5 wetproofed anode support means includes a wetproofed anode diffusion layer secured between an anode substrate and the anode catalyst.

20. The direct antifreeze cooled fuel cell of Claim 19, wherein the <sup>A</sup>direct antifreeze solution defines an antifreeze solution coolant stream flow pattern through the fuel cell that is transverse-concurrent to an oxidant flow axis defined by the process oxidant stream passing through the fuel cell, and wherein the reducing fluid stream defines a reducing fluid flow pattern through the fuel cell that is transverse-concurrent to the oxidant flow axis.

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